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IRRIGATION OF ORCHARDS BY CONTOUR FURROWS

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Many orchards in California are planted on hillsides where the frost hazard is low and land is less expensive. Irrigation on steep, irregular slopes is most effective when the water is distributed by contour furrows, and the tree rows are planted along the contour grades.

IRRIGATION OF ORCHARDS BY CONTOUR FURROWS[1]

M. R. HUBERTY[2] AND J. B. BROWN[3]

INTRODUCTION

During the past few years there has been a considerable increase in the development of hillside orchard planting. This development has come about through the recognition of the favorable situation of the foothills from the standpoint of frost hazard. Furthermore, many of the newer irrigation projects are located in the foothill areas where orchard management operations can not be carried on in the same manner as in the flat valley areas.

Contour planting, or the establishment of tree rows along grade contours of little slope, is one of the means used to irrigate hillside orchards more effectively. This system of orchard layout is adaptable to rolling topography where the cost of leveling would be excessive, and is particularly adapted to shallow soils where any considerable movement of the surface soil in leveling operations would expose bedrock or subsoil poorly adapted to tree growth.

TYPES OF CONTOUR PLANTING

In general there are three types or classes of contour layouts, as follows:

1. Uniform spacing of trees along a grade contour without regard to alignment.

2. Uneven spacing of trees along grade contour with straight crossrows.

3. Trees planted on varying grades with straight crossrows.

The three types are illustrated in figures 1, 2 and 3.

When the trees of an orchard are planted as in type 1, they usually do not form smooth curves along the contour nor are the crossrows straight. This method provides uniform grade in the furrows and reasonably uniform spacing of trees. The trees however, not being in straight crossrows, hinder cross cultivation and increase

[1] The information presented in this publication has been obtained by the Division of Irrigation Investigations and Practice and the Agricultural Extension Service largely from designers, owners and operators of contour orchards. In addition to the authors, Frank Davis, Junior Irrigation Engineer, Division of Irrigation Investigations and Practice, participated in the field work.

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the difficulty of detecting broken furrows which often occur in contour irrigation. As cultivation is generally in one direction only orchards planted in this manner eventually become terraced. This method is used when the planting is on steep, irregular topography.

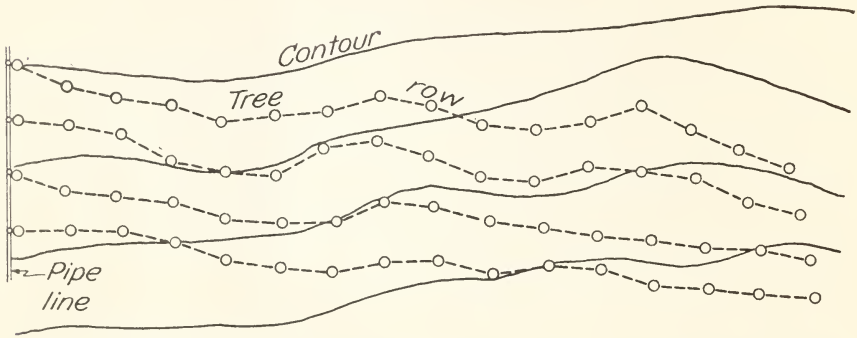

Fig. 1.—Uniform spacing of trees along grade contours; crossrows not straight.

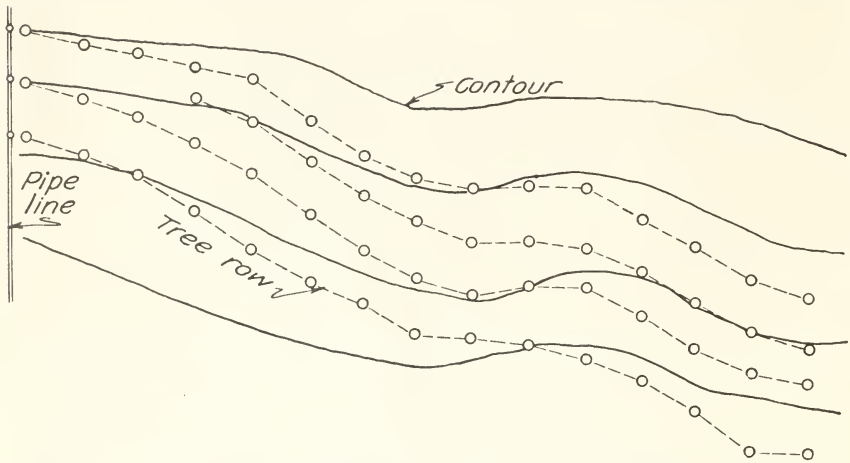

Fig. 2.—Uneven spacing of trees along grade contour; crossrows straight.

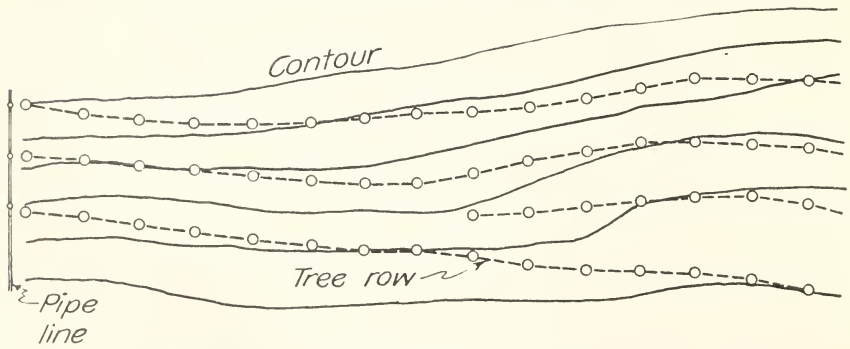

Fig. 3.—Trees planted on varying grades; crossrows straight. Tree rows along the contour form smoother curves than in types 1 and 2.

Type 2 differs from type 1 in that the crossrows are straight. On long, even slopes the crossrows can be placed parallel, or nearly so, while on knolls they are usually placed radially as there are more trees to the tree row at the base of the hill than there are at the top. This type of planting provides uniform grade and allows for cross cultivation, but at times it may result in a fewer number of trees per acre than with the first method. If cultivation in two directions is practiced, the possibility of forming terraces is lessened. In type 3 trees are planted on varying grades and in straight crossrows. This

Fig. 4.—Distribution of water from flume.

provides a smooth curve along the tree row and is an advantage in cultivating, but unless care is used, loss of grade may result from moving the trees too far transversely to the grade contour. This method can be used where the cross slope is not too steep and where the grade in the contour row is sufficient (1½ to 3 feet in 100 feet) to allow for a variance of grade.

THE WATER DISTRIBUTION SYSTEM

In the distribution of water to a contour planting it is necessary to have the water under control at all times. For this reason pipes or flumes are usually employed. In general, flumes (fig. 4) are in the way of cultural operations, but there is an advantage in their favor in that water can readily be delivered from them through

numerous openings into the furrows, thus lessening the tendency of too much water collecting in one furrow. The objection to the use of flumes is largely overcome when they are placed only along the edge of the fields.

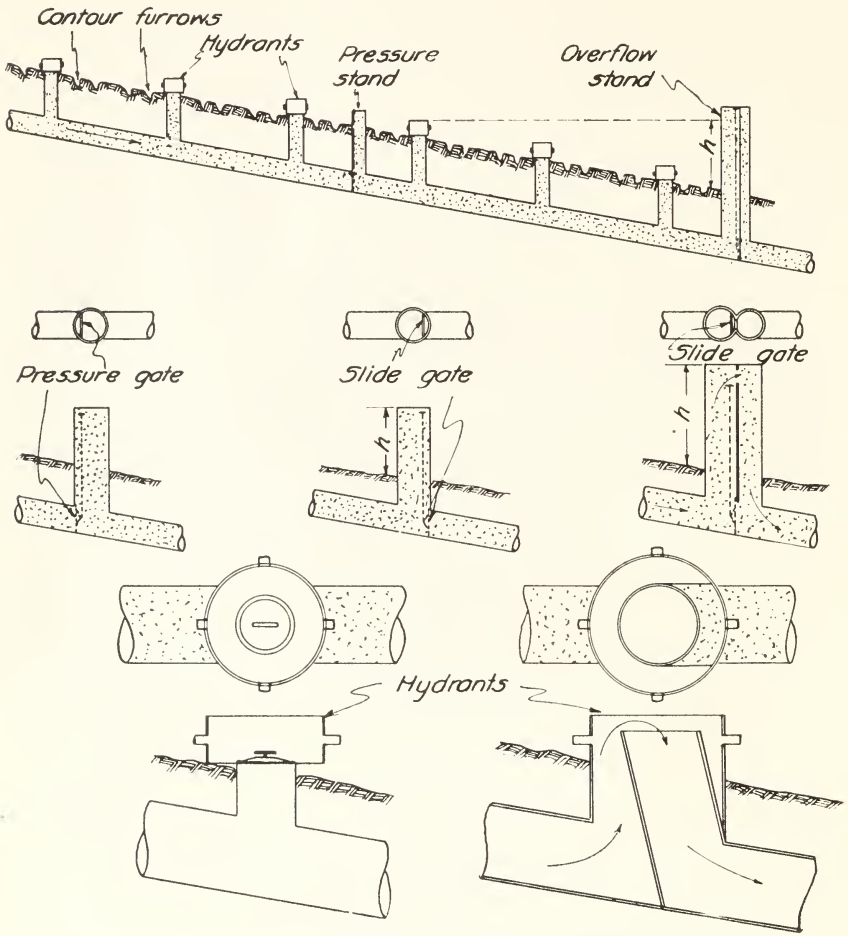

Fig. 5.—Types of concrete pipe distributing devices.

Pipes of iron, wood, burned clay and concrete are used in the distribution of water to contour plantings. When iron or wood pipe is used the common method of delivering water from the pipe line to the tree row is by means of a garden hydrant, but when burned clay or concrete pipe is used an orchard hydrant, or some overflow device, such as shown in the lower right-hand corner of figure 5, is usually employed. This type of hydrant allows water to be removed and excess water to by-pass back into the pipe line.

The distributing hydrants are usually placed far enough above the tree rows so that one furrow can be led from the hydrant to the upper side of the row. The number of spouts on the hydrant varies, but four represents common practice for contour plantings. Where more than one furrow to the tree row is being used some irrigators prefer to attach a portable distributing device to the hydrant. This device may be made in the form of a pipe or flume with openings spaced the distance between furrows.

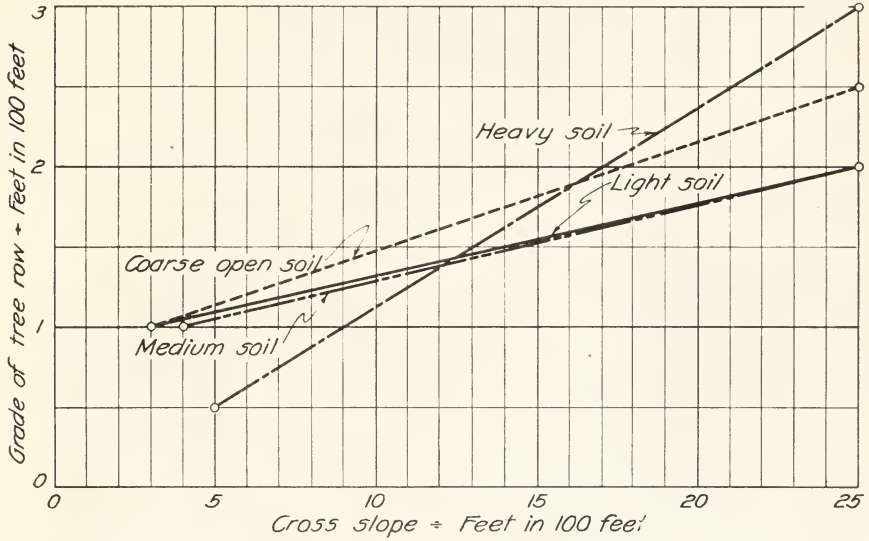

Fig. 6.—Desirable grades for contour planting. The horizontal divisions on the graph represent the slope of the land at right angles to the contour row, while the vertical scale represents desirable grade of tree row.

GRADE OF CONTOUR ROWS

The grades upon which the contour rows are placed depends largely upon the soil type and the amount of cross slope. The general tendency in the early development of contour layouts was to use grades that were too flat. Heavy soils take water slowly but they can withstand high velocities while light soils absorb water easily and wash readily. In any event the water must be so controlled that the quantities run in the furrows can be carefully regulated. Figure 6 represents desirable grades for the various soil types. For an orchard planted on medium soil where the cross slope of the land is only 4 feet to 100 feet, a grade as flat as 1 foot to 100 feet might be used. As the cross slope of the land increases the grade of the furrow should increase, so that on cross slopes of 20 to 25 feet to 100 feet a grade of

2 feet in 100 feet would be advisable. The table should not be interpreted too rigidly. It is meant to show within what limits it is desirable to work, and that the steeper grade of furrow is used with the steeper cross slopes.

It is desirable that no grade flatter than 1 foot in 100 feet be used. This will permit small deviations in the direction of the furrow and still give enough slope for water to flow freely. Also there is a tendency in time for shallow swale-like depressions to appear midway between crossrows and if the grade is too slight the water will tend to break out of the furrow at these places.

Fig. 7.—A pipe line placed down the average slope of a knoll as shown in the distance in the picture, and at the right in the foreground, allows water to be taken from it on both sides.

The heavy adobe soils in the citrus areas that are subject to "cracking" present a special case. If contouring is to be done on this type of soil the grades of the tree rows will have to be materially increased in order to overcome the tendency of the water to leave the furrow through the transverse soil cracks.

METHODS OF LAYOUT

A contour map of the area to be planted, while not absolutely necessary, will always prove helpful in determining the general plan of layout. In no case should one try to place the tree locations on the map and then expect to be able to go into the field and fix them

accordingly; tree location must be done in the field. As a rule the furrows will range in length from 300 to 600 feet, with the longer furrows being used on the heavier soils. The location of the water

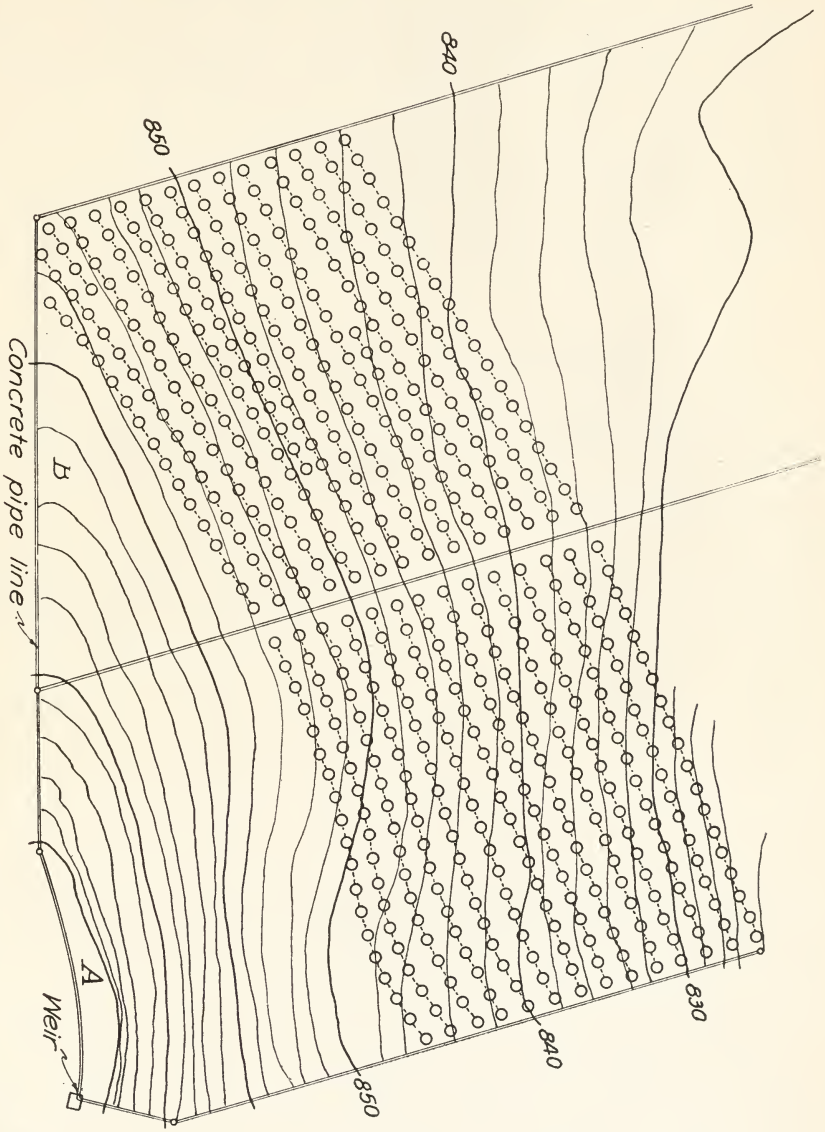

Fig. 8.—A type of contour planting for large tracts of uniform slope. (A part of the plantings of the Newhall Land and Farming Company, Ventura County, California.)

distribution system will be governed by the size and shape of tract, by the location of roads and natural drains and by the length of furrow runs. On small tracts the distributing lines may be run along a border, but in larger areas they may be placed down a ridge or across the average slope (figs. 7 and 8).

In figure 7 the pipe line is placed down the ridge. This allows water to be taken from the pipe in both directions. Run-off from the ends of the furrows can be discharged into natural channels and depressions. However, unless the run-off from the furrows is held down to very small quantities it is not safe to discharge it into a natural depression in the orchard unless an artificial drain flume is placed there. Figure 8 represents a long, even slope with the distributing lines placed approximately parallel. The run-off irrigation water from tract A passes directly into tract B. If the amount of waste water at the lower end of furrows is carefully regulated it is possible to continue these furrows a short distance into the next block.

LAYING OUT THE SYSTEM IN THE FIELD

When a general plan of layout has been decided upon, detail work can be started. The soil on side hills is usually too shallow to allow for much leveling so the common practice is to use a float or a drag to smooth the soil surface.

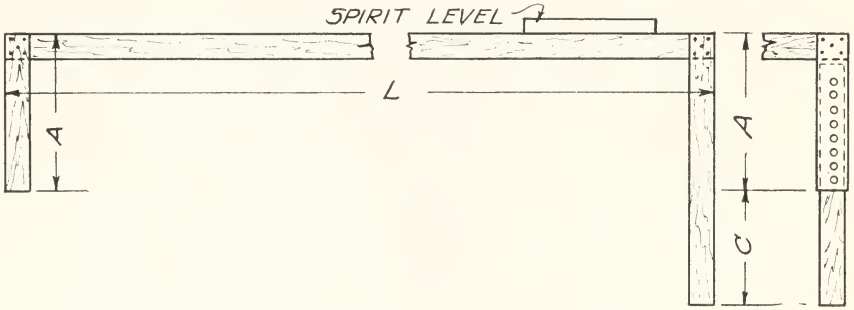

Fig. 9.—Grade board used in locating tree positions. The device is usually made the length of the distance between trees, represented by L. The short leg A may be any convenient height. The amount of fall in the length L is represented in the longer leg by C. If an adjustable leg is used, as shown at the right, the grade can be easily changed.

The tree locations may be determined by the use of a grade board (fig. 9), an engineer's level, or a hand level. Farmers as a rule prefer to use the grade board while engineers generally use the level or hand level. For the shorter distances of tree spacing the length of the grade board may be made equal to the distance between trees, but for the greater distances it is preferable to make the length of the board one-half the distance of planting. When this is the case the difference in length between the grade board legs is one-half that

listed in table 1. For the longer lengths it is difficult to make a grade board that is light enough to be easily handled yet rigid enough to give accurate grades.

Table 1 gives the fall within the distance between trees in the rows, figures for distances ranging from 18 to 25 feet and for grades of 1 to 3 feet in 100 feet.

TABLE 1

FALL OF CONTOUR ROW WITHIN THE DISTANCE BETWEEN TREES

Grade (Feet in 100 feet)	Distance of tree planting in feet															
	18		19		20		21		22		23		24		25	
	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.	Ft.	In.
1.0	0.18	2 3/16	0.19	2 1/4	0.20	2 3/8	0.21	2 1/2	0.22	2 5/8	0.23	2 3/4	0.24	2 7/8	0.25	3
1.5	0.27	3 1/4	0.28	3 5/16	0.30	3 5/8	0.31	3 3/4	0.33	3 15/16	0.34	4 1/8	0.36	4 5/16	0.37	4 1/2
2.0	0.36	4 5/16	0.38	4 9/16	0.40	4 13/16	0.42	5 1/16	0.44	5 1/4	0.46	5 1/2	0.48	5 3/4	0.50	6
2.5	0.45	5 3/8	0.47	5 11/16	0.50	6	0.52	6 5/16	0.55	6 5/8	0.57	6 7/8	0.60	7 3/16	0.62	7 1/2
3.0	0.54	6 1/2	0.57	6 13/16	0.60	7 3/16	0.63	7 9/16	0.66	7 15/16	0.69	8 1/4	0.72	8 5/8	0.75	9

The general procedure in laying out the distributing system and in staking out the trees is the same regardless of the type of contour planting selected. Start by locating the position of the water distributing line, then establish the line which is to control the spacing of the contour rows. This line, or control row, is perpendicular to the direction of the contour rows and is the base line used in spacing the contour rows. It should be located on the average cross slope of the area planted. If the water distributing line crosses the average slope of the area to be planted, then the control row can be established parallel with and adjacent to it. If the water lines are not located on the average slope, then the tree rows must be run in either direction from the control row. Mark the position of the first tree on the control row, then mark along the control row the intervals at which you wish to space the contour rows. These distances will not necessarily remain constant for as the work develops it may be necessary to make a slight change in spacing in order to do away with the use of a spike or stub row (fig. 10).

If a grade board is used, start by placing the short leg of the board on the control row at the location of the first tree, then carry the other end of the board around until the spirit level reads level and mark with a stake the position of the longer leg. This work is repeated until the end of the tree row is reached and then a new row is started.

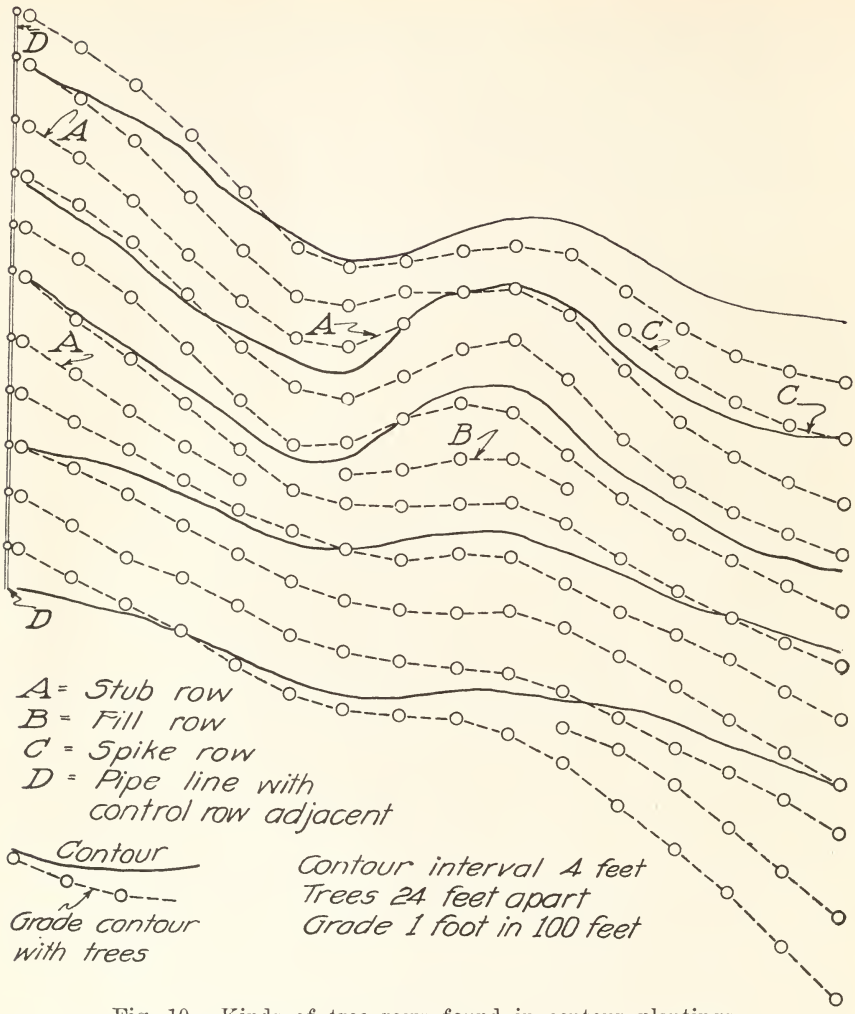

Fig. 10.—Kinds of tree rows found in contour plantings.

As a rule the rows will not continue at a uniform distance apart but will tend to crowd or spread, depending upon whether the cross slope increases or decreases. This can sometimes be controlled by changing the grade of the tree row. A change of grade will not always overcome the difficulty and in this case a tree row must be added or dropped, depending upon the particular conditions. For trees planted on rows 20 feet apart a minimum distance between rows would be about 16 feet, or a variation of about 20 per cent from normal. Should the rows tend to come closer than this the row should be stopped, forming a stub row. If the converse is true and the rows

diverge, a new row is started as soon as the spacing is great enough so that crowding will not result. Rows placed at the ends of the runs for the purpose of filling in open spaces are called spike rows. Sometimes the rows tend to separate near the middle of the runs and then a short row, or fill row, is used. This is a particularly objectionable row as it increases irrigation and cultivation difficulties.

Fig. 11.—The modified basin method of contour irrigation.

If a constant grade and spacing have been maintained the trees will not be in straight rows across the contour, but will be as described under type 1 (fig. 1). By using a hand level the crossrows can be straightened if care is used not to move the trees too far off grade so as to cause a loss of grade along the contour row. The planting will then be as described under type 2 (fig. 2).

If a surveying instrument, transit, level, or hand level is used the same initial procedure is followed as for the grade board. The control row is chained, whereas the instrument is used to "run in" the grades. On large tracts of fairly uniform topography some surveyors prefer to stake out every fourth row and then give proportionate distances to the other two rows with the chain. This method is faster but should be used only on uniform topography.

A third method used by surveyors is to establish a control row down the average slope. Guide lines at the top, middle and bottom of the slope are then run at right angles to the control row. On these three lines markers are placed at the same distance apart that the trees are to be placed in the contour rows. With these markers as a guide the rodman will be able to mark the tree location in the contour rows when the levelman tells him he is on grade. This method produces a fine type of planting but usually results in a fewer number of trees to the acre than is obtained by some of the other methods.

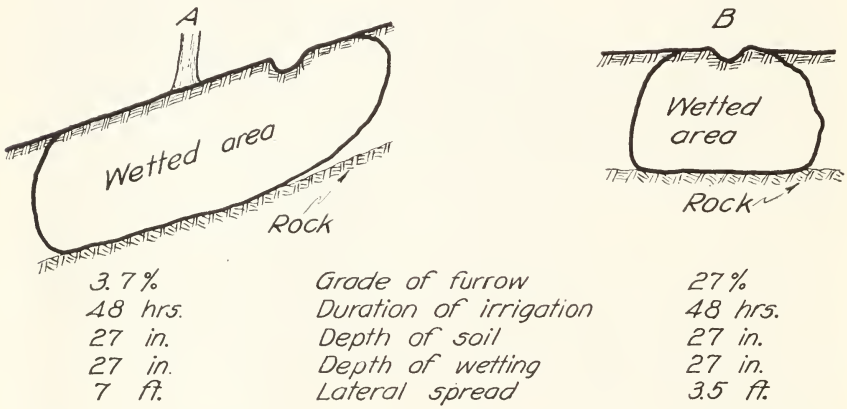

Fig. 12.—Distribution of moisture in a shallow soil; A, contour furrow with a grade of 3.7 per cent and with a cross slope of 27 per cent; B, straight furrow with a grade of 27 per cent, but with no cross slope.

CONTOUR PLANTING COSTS

The leveling done preparatory to contour planting is little more than smoothing the soil surface and in many cases where the field has been previously planted to field crops no leveling is done.

The staking costs, where the work is done by the use of a grade board, may vary from $1 to $5 an acre, depending upon the topography of the land and the experience of the men doing the work. Layouts made with engineer's equipment as a rule cost more than those made with the grade board. These costs range from $5 to $15 an acre.

IRRIGATION PRACTICE

The irrigation of contour orchards requires more care than for straight plantings as there is always the danger of the water breaking from the furrows and flowing directly down the slope. Some irri-

gators allow grass to grow between every other pair of tree rows as a protection against damage from broken furrows. Added to the above-mentioned trouble is the difficulty of taking care of the run-off from the stub rows and in getting water to the spike and fill rows.

The number of furrows used to the tree row varies from one to eight, depending upon the age of the trees, depth of soil and steepness of cross slope. On the shallow soils on steep grades the water tends to move laterally, or to sub-irrigate, so fewer furrows are used.

Fig. 13.—Terraces produced by plowing in one direction along the contour.

A modified basin method of irrigation is practiced by some orchardists. In orchards that have become partially terraced, either through cultivation or leveling, basins are made on the upper side of the tree rows. A deep furrow is made on the upper side of the basin and from the furrow water is allowed to enter the basin. Figure 11 shows the method in use.

The efficiency of irrigation on steep slopes is much higher with contour planting than where furrows are run straight down the hill. Figure 12 represents the distribution of moisture in an Aiken loam soil; first, where the irrigating is being done by running water down a 27 per cent grade and, secondly, where the cross slope is 27 per cent and the furrow grade is 3.7 per cent. The data are from experiments made by the Division of Irrigation Investigations and Practice.

CULTURAL PRACTICES

Cultural practice in contour planting varies, but as a rule little cross cultivation is done on the steeper slopes, the weeds between the trees being removed by hoeing. Cultivation along the contours produces terracing unless the practice is to plow so that the soil is thrown up the hill. Figure 13 shows the terracing produced on a contour orchard. If the cross slope had been greater the terracing would have been more marked. Where heavy rains occur terracing is very desirable as it materially reduces erosion.

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